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Original Article

STUDY OF FAULT DIAGNOSIS AND DETECTION MECHANISM IN MACHINES

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ABSTRACT

Faults in machines are frequently causing reduced productions and increased protection costs in various industrial applications. In industrial area, the gears and rolling bearing damages are one of the most significant causes of breakdown in rotating machines, and it causes reduced production and increased cost. The different types of machines are used in industries for different applications. The gear box includes three major issues like overheating, oil leakage, and excessive noise. So the high demands of vibration condition is dependent on the monitoring of gears and bearing and some methods are used to enhance the effectiveness, reliability, and accuracy of bearing faults diagnosis. The optimization techniques are used to optimize the features and classification techniques are used to classify the signal as health and faulty signal. These outcomes are used to identify the faults or cracks which are present in machine. The benefits of fault detections have reduced the cost of production and, it also reduces the overall cost. This review paper, examines the fault diagnosis methods and their application in various industries. The fault identifications helps in reducing the production time, but it is challenging to handle it in a very large industry. The problems are connected with detection methodologies, and the arrangements are commonly investigated for all types of utilization. This paper reviews the merits, and demerits of fault diagnosis system, optimization techniques, and signal classification techniques.

KEYWORDS: Gear Box, Fault Diagnosis, Optimization Techniques, Classification Techniques & Gear Tool Box Faults

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1. INTRODUCTION

A machine which is also referred to as mechanical device utilizes the power for applying forces and control movements which [1] helps to perform an intended activity. Generally the machines are driven by the people, and animals, by utilizing the natural forces like water, wind, electrical, thermal, and chemical power. It also comprises of a system of mechanisms which helps to shape the actuator input for attaining a particular application of output forces. It helps in makking the products available with high quality, reduced cost and results in safe productions. It has improved the changes of machine preservation approach for real time fault diagnosis. The faults [2-4] in rotating machines which causes the failures in the components of gear box is due to their damage. Fault diagnosis is a significant methodology that prevents the gear box resulting into serious damage. Early detection of defects are critical to prevent the system from malfunction which results in damage. Diagnosing a gear system to examine the vibration signal technique applied usuallty for sensing the gear failure [5]. Time domain technique, frequency technique and time-frequency techniques are some methodologies for processing the fault diagnosis. Different kind

of faults occurs on gear tooth that includes one corner fault, two corner defects, three corner defects, and missing tooth. AE's signals are used to identify and analyze the faults which are located in the machine. The span acoustic related to the pressure waves are not only the pressure waves, but also the elastic waves. The stress field [7], local condition of the region and their physical state is used to identify the occurrence of energy burst. But this cannot regulate the exact details and time of the waves that are generated. In common, the emission which is generated is irretrievable. When the elastic wave is generated, the wave is transmitted throughout the material and is sensed at a distance in a particular origin. The movement of wave is exposed to overall variations as well as characteristics of their acoustic path while traveling from source point to the destination point. The variations like both the microscopic and macroscopic deviations in the association of the material is used for the attenuation of the energy. While the disturbance level is identified by the amplitude, the excitation of a sensor requires the things which are occurred in the sensor. Both sensor characteristics and wave path to each sensor are applied to modify the source location and all other characteristics of the detected signals. AE's signals are mostly used in many applications[8] like, crack detection, leakage identification[9], weld analysis, vessel inspection, pulp and paper industries, and aerospace industries. Many feature extraction and classification techniques are used to classify the exact signal to identify the faults. The aim of this survey towards the different techniques and methods to provide well standard fault detection and diagnosis methods. In this process, the various issues in fault diagnosis and classifying signals are analyzed. The various existing approaches and their goodness and loss of credit were analyzed. This survey is well structured as follows. The section II exhibits the previous work in fault diagnosis. Section III deals with Short Time Fourier Transform (STFT). Finally, remarks of fault diagnosis, optimization techniques and classification techniques are presented in the section VI.

2 RELATED WORKS

2.1 Gears in Industrial Application

Four magnetic Gears were independently implemented the Alnico, Ferrite, NdFeB and SmCo were used to analyze. The non-rare earth PMs centered magnetic gears were provided with the less performance compared to occasional earth PMs based magnetic gear. The non-rare earth PM centered magnetic gears significantly offered the lesser result compare to air gap flux density rare earth PM based magnetic gears. NdFeB built magnetic gear yielded the utmost steady rotating force. The cost effective performance was offered by non-rare earth based magnetic gear and also it offered the low output [10]. A group of accurate machine setting was used to manufacture the hybrid gears centered on nonlinear examination and also the usage of computational algorithm was determined by tooth flank structure alteration. The remaining ease-off was recognized by applying the standard model of tooth flank topography. The nonlinearity problem was solved by using algorithm and it was offered the high efficiency, and robustness in hybrid gear design and manufacturing [11]. Data-driven programming was used to design the cooperative industrial scheme for HCIs. The hypoid gears were offered the symmetrical tooth and contact performance. LTCA and DTCA were used to integrate the high order alteration of optimum device. CAD\CAM\CAE\CAPP scheme was not need the samples, but fault methodology demanding samples [12]. The motor fault detection was identified by suing motor current signature analysis (MCSA). Some applications were used to analyze the electrical current of local gear faults diagnosis. The system was composed by low voltage AC motor which was run by pinion via reduction gearbox. The operation was observed for identifying the irregular and actual casual differences of sudden current fascinated by motor, and it was used to measure the stator phase current. The ball mill mechanism was derived by two AC motors, and also, it had two stage reduction gearboxes. This method failed due to some limitations like moment of inertia, effect of coupling, frequency of torque fluctuation [13]. It was included numerous malfunctioning of

gears which was support to state the efficiency of the techniques to detect the large variety of liabilities in motor. The information was gotten with some technique which was to make probable to discover the fault in the diverse nature. The main advantage of this technique was that it offered the useful data to identify the numerous faults in machine. It helped to identify the motor health. The infrared inspection of motors was enabled to identify the numerous kinds of letdowns in an inspected motor with altered reasons. These techniques were capable to perceive the fault as manner lubrication letdowns, difficulties in diffusion system, faulty networks, preservation scheme problematic, and also presence of stator winding problems. The false alarm was caused by some reasons and infrared thermograph was an exception. The motor over heating was one of the reasons that was related to fault like operational overhead. The presence of altered thermal patterns was cast-off to distinguish between the motor failure and irregularities which was not related to motor. These techniques were permitted an instinctive analysis of infrared images and it analyzed the disorder discerning among the responsibilities and other properties [14]. The balance manipulator was developed with an effectual limitation of bouncy gears and electrical initiatives of load vertical navigate. The electromechanical force compensating system. It was minimized the applicability of nonreversible motor and low torques, vigorous restriction of dynamic efforts by consuming electric drive. The issues were used to recover the strategy of electromechanical system of distinct elating strategies, manufacturing manipulator and robots, simulator complexes and testing workbenches. The selection of preferred fall radius value of gear from permissible value assortment was categorized into two [15]. An intelligent condition monitoring system was identified the general faults which was produced in the process of bearing in an industrial root joints like inner or outer race bearing. By using Discrete Wavelet Transform (DWT) the most salient features were related to faults are extracted.. The faults were classified by using Artificial Neural Network (ANN). The vibration signals were taken from robot when it was moving joint cyclically. Robot arms displayed the difficult active performance and dissimilar faults caused by this behavior. The motion was entirely different from rotating machines. Wavelet analysis was represented an effective method for non-stationary signal. The faults were classified by using artificial neural network (ANN). The vibration signals were taken from robot when it was moving joint cyclically. Robot arms were display the complex dynamic behavior and diverse faults were cause by this behavior. The motion was entirely different from rotating machines. Wavelet analysis was represented an effective method for non-stationary signal. ANN was skilled to differentiate between altered kinds of fault in the robot [16]. The wind generator scaled model with integrated system of piezo-flim deformation sensors for verifying the solution of SHM and diagnostics of an industrial structure. Simultaneous and multi-patch Operational Model Analysis (OMA) method was implemented for structural diagnostics and monitoring. The single vector change assessment parameter was used to monitor the structural condition, and it was analyzed the dramatic change of model characteristics of modified object. MPVI models were analyzed for identifying the localized defects. The drawback of the work was required to improve the feature multi-path OMA damage detection process [17]. The motor was associated with cycloid pinwheel reducer by a belt drive related to non-circular gear reserving box of core over a coupler. The two speed communication was used for removing the device stroke which was connected among the periodic rotation shaft and cylinder. When the motor was in progress the power was conveyed to non-circular gear retrogressive box. The production shaft drive the tube to complete a cycle of positive and negative revolution for apiece response shaft exchanges for single circle. ADAMS was used to analyze the entire non-circular reversing gear train. The work presented the high accuracy rate and it offered the efficiency of new type machine which was 11% higher than traditional walking beam type pumping unit [18]. A model based approach was termed as PbM approach and it was used to analyze the well-being of the system for resolving a group of equation which was resulting from engineering and science for diagnostics or prognostics. The merits of PbMS were used for the deprivation models to forecast their long term behavior. The development of PHM system was established on

the physics, and it was used to analyze the failure modes, and degradation tools. A variety of failure mode was analyzed with rotating machinery components. Vibration analysis and AEs were the main diagnostics and prognostics methods for gears. PbM methodology was generally included with dynamic model of the system which relates the vibration indication with strains, and crack development model. The fault identification and isolation were done by the general component and their amplitude of natural frequencies and rotating component. DDM method was used to measure the AEs or metallic and vibration analysis[19]. Taguchi approach was robust and statistical methods, were allowed for the independent estimation of response with less number of experiments. This approach was provided to support the influence of different factors on desired faults, so, it was more economic quality characteristics. Taguchi method solutions offered for certain problems. Taguchi method provided the benefits of the surface durability of gear tooth and reduced safety coefficient. The C factor or gear width was statically significant for safety coefficient for surface durability of driving gear tooth. The quality characteristic was predicted in chosen range of their considered factors[20]. The gear cutting process was used to improve the production of apparatus and resources for cutting rudiments of hob milling tools. Hob milling procedure was mostly used to link the chain of gear machining. The optimization of the manufacture circumstances for gear cutting of tubular gears was based on large level on the precision of assortment and conservation of hob milling tool. The output and cost efficiency of hob milling was resolute by the features, construction features, and substantial of cutting edge. The application of hob milling tool was coated with TiAIN that offered bettered result [21]. The online compensation of machine deviation approach was based on the measurement six-axis robot compliance model. A standardization process was labeled and it attained the dimension matrix for authentication procedure. The standardization tool was used for perpendicular cutting processes. The sensing devices were validated by using an aluminum cutting operation and it was able to measure the process of force with good accuracy for the purpose of compensation. The sensing rod holder was enhanced to attain advanced straining at the capacity location. The higher sensitivity was used to reduce the noise in signal and also achieved a higher correctness in power dimension [22]. The work was used to widespread the ISO average control process for different request factors of variable amplitude load. An industrial vehicle was subjected to work in real time application. The substantial difference was among the ISO standard and Wohler damage line of material and specific fatigue curve of component[23]. It was used to cut the common standard gears. The properties were analyzed, and also the flank load carrying capacity of gear was also derived by trials on back-to-back test benches. The combination of soft and machining tools were provided with the merits over the conventional process chain even for manufacturing huge size of gears, and single part production. Five axis gear milling was offered the opportunity for extra degrees of freedom in gear and part design. Then the microgeomertry of tooth flank and tooth root were optimized freely. The manufacturing process was based on machine tool and the control unit was comparable with manufacture of models and dies of impellers and turbo machinery components. The process characteristics were free from the milling of gears, and also, it included with tool selection, generation of input data, and machining strategy. The gear quality was included with four variants and it was made by multi-cut strategy. The process-specific surface structure was varied by line-ness. The measurement of depth profile was a closer look for the properties of surface near area. The direction of tool feed was lead the direction and it was equal for all machine parts. A Full Width at Half Maximum (FWHM) analysis was applied to detect the micro-residual stresses, and homogeneity of material structure. A chosen to manufacturing parameters were used to influence the surface near properties of microstructure[24]. The accountability signature was connected to gear tooth exterior and the faults were predicted by numerical simulation. The SCSVIF was included in the data which was related to mechanical torque investigated by compelled electrical mechanism. In limited gear condition, the additional elements were appeared in the mechanical rotation by determined electrical mechanism by owing the attendance of rotation influence which induced a

periodic responsibility signature augmented by tensional natural resonance. [25] the model was used to create the spur gear model for sufficient usage of extrusion operation. The spur gear was developed for standard means of auto desk inventor tooth profile surfaces which were entirely fit the profile. The angle of tooth was given through the step helix and length of pitch circle. The solid module of gear with more complex geometry surface of teeth was created. [26]. Automatic acoustic emission detection techniques are used to identify the metallic fatigue fractures. In noisy environments, the fatigue fractures were identified by using acoustic testing. In the complex test environment, the fracture was validated by using gear components. The disadvantage of the AE was only to identify the damage in the material. So it was improved by the quantitative results [27]. An acoustic emission signals were used to monitor the fluid magnetic abrasives finishing process, and the materials were removed by mechanism which was utilized in FMA finishing process. RMS measure was used to measure the irregularity of surface, and it was high reliable one[28]. The quasi static identification (QSI) tests were conducted with online acoustic emission monitoring to simulate the composite laminates. Cumulative energy, cumulative amplitude, cumulative raise time was considered as AE parameters of QSI loading[29]. It was used to identify the fatigues, and cracks in different types of materials. Cyclic loading, crack closure, crack initiation and ultimate failures were caused by fatigue test of AE signals. The safety of steel structure was monitored and it detected the cracks or crack growth in the material[30]. Air present in the nanotube led to decrease in mechanical performance of mortars. Mechanical and fault performance of mortars were assessed the AE techniques[31].

2.2 Short Time Fourier Transform (STFT)

The entire signals could be exclusively detected by STFT magnitude in mild directions. The STFT retrieval issue was quadratically constrained problem. So these techniques was termed as lifting. It was offered the solution for convex program with rank-one matrix, and it was one of the perfact solution to quadratically-constrained issue. [33] STFT was enabled the unique recovery for arbitary nonvanishing inputs in mild condition, An efficient algoruithm was used to recover the sparse input from STFT magnitude and it was based on adaptation of GESPAR algortihm. The sparse singals form STFT magnitude was recovered from fourier magnitude fails. In optics, the small variation of GLA was used and it was referred as Principal Elements Generalized Projections (PCGP). The oversampled DFT was used to offer the better performance by using STFT. Here the redundancy is attained with the capability of GESPAR dimensions and rare input provided the great prospect of recovery process. [34] the work was incoperated with three interrealted algotihms and it was used to estimate the signals efficently from noisy measurements by solving a simple least squares (LS) problem. The least square method provieded the stability guarantees and no prior infomraion is required on sought signals. But the recovery offered the guarante under relatively strong restrictions on STFT window. Next algorithm was used to recover the non-vanishing signals in efficient manner from noise free measurements. A Semi-Definite Program (SDP) was used to offer the sinal robustly and it was free from noisy measurement.[35] These processing steps were used to remove the undesired signal. Windowing 2-D entropy method was used to measure the uncertainty associated with random variable. The high and low entropy value indicated the high degree of data. In homogenous data, the B-scan image was segmented into three region consisting of classes, such as, singular, stationary background region and transition region. OYSU method was used to extract the object from its background. The intensity value of variance of dame region was minimized when the variance of different regions were maximized. The usage of entropy analysis was effectually reduced the data volume for the procedures of postprocessing. [36] the wind turbine gears boxes were monitored for identifying the fault which was presented in the turbine. The gear box systems were included with nonlinearlites and also the time frequnecy analysis were utilized. Empriical Mode Decomposition (EMD) techqnique was applied for decomposing the vibrational signal into

meaningful signal component which was related with particular frequnecy bands of the signal. The signal components were produced by amplitude frequnecy demodulation and standard method was used as Hilbert Transform (HT). Theroretical model could be categorized as linear and non-linear time varying. In this process, the gear tooth was damaged and then it scrutinizes the definite frequencies related with meshing frequencies and their harmonics of definite stages include the gear damage. The time frequnecy analysis was performed with TKEO methodology was efficeinetly extracted the damaged features. The sudden frequencies were used for extracting the features so that frequency drop appeares at similar IMF. [37]. The outlier of Short Time Fourier Transform (STFT) amplitude series were preprocessed with information entropy. The methods were applied to mine the defective frequnecies over restored vibrating signals through TSK filtering. The bearing defects were categorized by multi class SVM. The real wheel bearing vibration signal was illustrated effectively. The possible outliers with entropy was used to detrermine the signals Power Spectrum Density (PSD) in Probability Density Function (PDF). An entrophy is computed with the various methods like approximate entropy, spectral entropy, multiscale entropy and energy entropy. The vibration occured in the specific characteristic frequnecy that was determined through roational speed, localities of defects and geometric structures. The outcome of the method offered the high accuracy for faulty frequency detection and it was classified with the four conditions for roller bearings [38]. The usage of Empirical Wavelet Transform (EWT) that utilized the wavelet filter bank entirely was based on signal with HT in initial identification and condition monitoring of tooth crack fault. The outcome of pinion vibrational displacment was applied to identify the tooth crack damage as healthy and defect gear box. The HEWT was more considered and it was more appropriate for identifying the effect of tooth crack in vibrational signals, and it offerd the high readability of time frequenecy representation.[39] A novel methodology for local fault idenfication based on distribution distance and time frequnecy decomposition. The local damage in bearing or gearbox offered the specific response in vibrational signal. It was not performed the simple impulsive event which affect the signal and not perform correctly in standard analysis. In general transformations were used in the vibrational signal analysis for time frequenecy decomposition via STFT. The energy distribution from spectrogram matrix was used in this work. The high energy bands had an effect on the outcomes, so, it was required to preprocess the signal before calculating the distance measures. [40] surveyed the short time fouirer transform based SK, kurtogram, adaptive SK and protrugram and their application based on fault identification and analysis of rotating machines. In addition, the potential prospects of prognostics were also reviewed. The vibrational signals were analyzed by using the Spectral Kurtosis (SK) technique. The SK was termed as kurtosis of their frequency elements and it was analyzed with variability in amplitude of different spectral frequencies. So the statistical parameters were represented signal varies with their frequency. The practical vibration signals were provided with addaitive nosie so it was considered as CNS nature. The operation of Adaptive SK (ASK) technique was identified as the center frequency and the window length through the greedy approach. The rotating machine fault diagnosis was used in different aplications like, bearing fault, combined different method to identify the bearing fault, and to identify the tooth faults in gearbox. These applications were mainly based on the great ability of SK identification of impulsiveness.

2.3 Frog Leaping Algorithm (FL) in Fault Detection

Minimum Entropy Deconvolution (MED) was applied for an objective function technique to design the filter coefficient and suitable threshold value were set in the evaluation process to attained the effects of optimal iteration [41]. The improper setting of threshold affected the target function and it was recalculated. MED based technique was applied to remove the feature elements from rolling bearing vibration signals which was originated from high noise environments. The optimal filter coefficients were identified by using Shuffled Frog Leaping Algorithm (SFLA). Deconvolution was one

of the inverse filters which was used in seismic data for recovering the reflection coefficients. The usage of analysis in seismic reflection pulse and enhanced estimation of subsurface reflection interface the reflection coefficient. The deconvolution was used to extract the interferene form short cycle and numerous waves. Deterministic and predicitive were two types of deconvolution process. SFLA was group of the global breadth search of whole frog populations and local depth search of frog. The frog illustrating the solution was categorized into multiple subsets, and each population had their own culture. SFLA was used as the selection of filter coefficient and it was more flexible. There was no extra frequnecy elements behind the characteristics freqency which appeared in the spectrum of envelope. [42] a Fuzzy Rough Set Procedure with Binary Shuffled Frog Leaping (BSFL-FRSA) for recognizing the variables and it described the objective rate of drives to NEE. The outcome of BSFL-FRSA was effectually recollected the most data by utilizing limited variables and it achieved the better outcomes. Eddy flux was calcualate the exchange of CO_2, water vapor and energy resultant from convariance of high frequency fluctuation in vertical wind velocity and CO_2 concentration. The efffects of single variables and the methodology was evaluated with significant variable combination. The function of selecting variable was to reduce more variables and also maintaining the acceptable sufficianet data. the grouping of soil temperature and net radiation and soil water content were evaluated for identifying the strong influence on NEE. [43] The Shuffled Frog Leaping Algorithm (SFLA) was meta-heuristic to manage the different optimization difficulties. SFLA was included with benefits of advantage of memetic prodecure and Particle Swarm Optimization (PSO). SFLA was utilized to resolve the multi-objective optimization issue, and it improved the local and optima, falling computational time and superiority of initial population. The traditional and non-traditional procedures were used to solve the different optimization problem. The algorithms were established on some key elements.

Table 1: Different Application types for Applying SFLA [43]

No	Application Type
1	Feeder reconfiguration problem in distribution network
2	Water distribution network optimization problem
3	Detection of fault location in distribution netowrk
4	Elecrtical power flow optimization
5	Continous optimization problem
6	Finance-based\project scheduling problem
7	Traveling salesman problem
8	Volt\Var control problem in distribution system
9	Classification problem
10	Knapsack problem
11	Distribution expansion planning problem
12	Optimization of stable points for poly vinyl acetate
13	Optimization of UAV flight controller
14	Sequencing problem
15	Economic load dispatch optimization problem
16	Flood control problem
17	Optimization of parameters of induction machines
18	Optimization of fuzzy controller
19	Production planning problem
20	Power system stabilizer

Time Frequency Distribution (TFD) with Non-Negative Matrix Factorization (NMF) and a novel TFD matrix factorization techniques were used to improve the illustration and detection of behavioraldamage. TFD of vibration signal was defined the damages. The directed NMF mapping was used to remove the fault feature from TFD. Fault elements were grouped and detected by utilizing the property of NMF clustering. This appraoch could be express the variations that was

made the diagnosis more easier and it was more reliable. STFT was time frequency analysis methodology that was mostly applied in signal processing field. Non-negative Matrix Factorization (NMF) was matrix factorization methodology with non-negative elements. The NMF used for clustering the non-negative data. The fault diagnosis methodology had two stages such as, fault diagnosis system based NMF, and fault recognition. The Artifical Neural Network (ANN) was applied to detect the damages in the application of rolling feature bearing faults, procedure were discoved the low-dimensiional feature spaces. The feature extraction and recognition capacity of method was superior to ANN[44]. Reviewed the fault diagnosis by computational intelligence. The fault mechanism and recognitionmethods were combined in the fault diagnosis. It was depended on theory of signal processing and pattern identification. Different procedures were depending on computational intelligence for fault diagnosis. Artifical Neural Network (ANN) was one of the special case of neural computation. Analytical inference could be used as the solution of problem based on certain mapping association among the indications of damage and their causes. The difficult mechanical system was mapped and the connection was generally nonlinear[45].

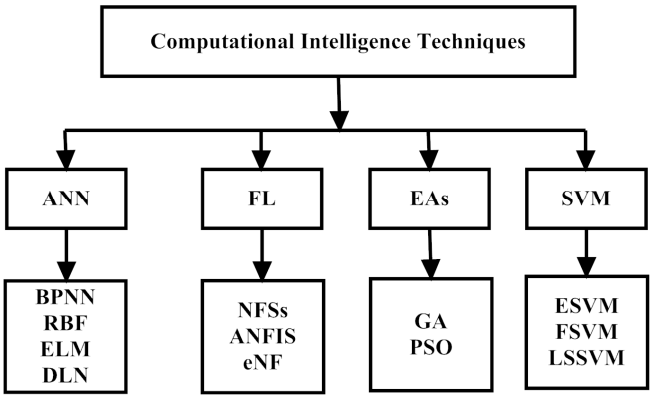

Figure 1: Computational Intelligence of Taxonomy [45].

The signal processing techniques, the fault feature extraction was optimized and it was considered as an objective function. Fault feature extraction process was mostly used the Genetic Algorithm (GA) and Particle Swarm Optimization (PSO). EAs mostly utilized the fault diagnosis by different procedures. EAs was applied to enhance the structural parameters of machine learning procedure. The actual application of mechanical engineering was difficult in the condition monitoring.

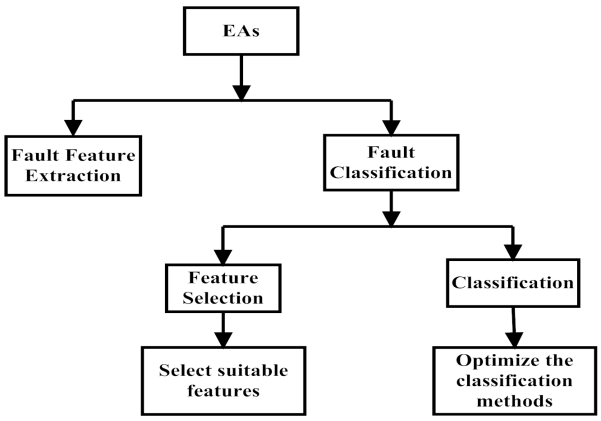

Figure 2: EA used for Fault Diagnosis [45].

The spectral kurtosis by means of location was used to strategize the system with healthy signal. The stator current instantaneous frequency was used to evaluate the motorized disturbances. The normalized behavior of indicator

was more confirmed for various operating conditions. The observation of electrical machine and phase current was noted for certain amount of time period with regular intervals. The different faults were occurred in electro mechanical scheme produce the signals with stationary behavior. [46] An efficient technique was used to calculate the double-cage induction motor by using the artificial bee colony (ABC) procedure. Scout bees were frequently searched the outdoor to find unseen food source. In ABC procedure the position of each food sources were identified the point in domain of problem and the minimum value of cost function was assumed as better food sources [47]. A constrained optimization issue with unknown parameters was calculated as sum of square of differences among the starting torque, nominal and maximum torques, maximum currents and nominal power factors of a model and manufacturer data was minimized. ABC was more effective tool for parameter evaluation, and modeling of double cage induction motor. [48] Surveyed the micro crack growth at various phases of smooth specimens of structural steels. The micro crack length, total amount of micro cracks, and relative portion of injured surface was projected by acoustic emission. This technique was found to have magnetic characteristics of metals, velocity, attenuation of longitudinal ultrasonic waves, and these are considered as time dependencies of acoustic emission parameters.[49] Based on the Deep Neural Network (DNN) was trained with novel intelligence method and it had two shortages of ANN in fault analysis of rotating equipment. The fault feature extraction on intelligence diagnosis was used in DNN techniques. The unsupervised layer by layer learning was retrained by DNN, and also with supervised procedure. The advantage of this method was,

- It was capable to adaptively mine the fault characterisitcs form measured signals for different diagnosis problems.
- It was beginning the non-linear mapping linked among the diverse health situations of technology and it was based on their measured signal.

The main components of rotating machinery were rolling component bearing and gears. In some times, the health conditions of these components were affected by their performance, reliability and service life of machinery. These components eaily affectsed from various types of damage, breakdowns and more economic losses. The efficiency of the method was evaluated by five dataset from rolling portion of bearing and planetary gearboxes. The technique was required the minimum signal handling methodologies. Hyperbolic tangent operation was used as active operation of DNNs. Here the half coefficient of frequency spectra was utilized because the coefficients were symmetric in the spectra. [50] This work used the vibrational signals and deep learning Conventioanl Neural Network (CNN) for identification of fault and gearbox classsification. Some basic fault conditions were based on the combination of a different condition patterns and the analytical measures from time domain signals like standard deviation, skewness, and kurtosis. Convolutional layers were moved forward with deriving the back propagation update in netwrok that was composed the feature map by using convolving kernels. The gear box conditions were reflected by the data which was included with different features in time and frequency doamin. The group of signals is obtained from the measurement of vibrations at various speeds and loads, and moreover, the feaures were obtained from frequency and time domain. The classifiers were made the contribution to maintenance routines for industrial system for lowering cost and continuous production scheme. [51] A Convolutional Neural Network (CNN) was absorbed the elements straight from frequnecy infromation of vibration signals.

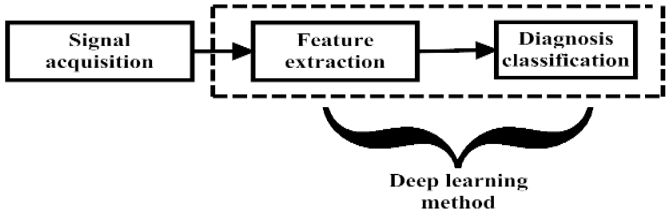

Figure 3: Mechnaical Fault Diagnosis – Deep Learning Application [51].

CNN offered the capabilities to extract the features, classification, and selection process in an end to end machine learning scheme. It was operated the raw data as response, and provided baisis for the analysis outcome. The classification techniques of CNN was offered the best correctness with frequency spectrum data between various datatypes. The CNN module was appropriate to study the structures from their vibrational information.

Table 2: Pattern Label Description of Planetary Gear Box [51]

Pattern Label	Gearbox Condition	Input Speed	Load
1	Normal	10,20,30 Hz	Zero
2	Chipped tooth	10,20,30 Hz	Zero
3	Pitting tooth	10,20,30 Hz	Zero
4	Chaffing tooth	10,20,30 Hz	Zero
5	Weak root cracked tooth	10,20,30 Hz	Zero
6	Root cracked tooth	10,20,30 Hz	Zero
7	Worn tooth	10,20,30 Hz	Zero

Table 3: Comprehensive Review

Ref No.	Year	Description	Advantages\Disadvantage
[52]	2014	The wavelets are used to analysis the signal with the purpose of fault diagnosis in rotary machine. The fault analysis was considered into four as, CWT-based, DWT-based, and WPT-based and SGWT based fault diagnosis. The wavelet techniques were accurately identifying the machine faults.	***Advantage*** It compress to offer the accurate data I energy localization of time and frequency domain. The desired data of signals are low and high frequency bands. ***Disadvantage*** It was computationally intensive It was require more time for select the particular wavelet for proper signal.
[53]	2018	The simulated signal and real data studies were showed the capabilities of MSB-SE exceeds that of kurto gram based detectors the request to signals from terrestrial gear box, and this technique was used to detect the bearing faults in circumstances.	Advantage It could be sense and illustrate transients signals Disadvantage It requires an exact band pass filter to develop then it required to incorporate the different techniques.
[54]	2017	This technique was used to detect, classifying and perhaps to remove the harmonics and side bands in vibration and acoustic signals.	***Advantage*** It was sense periodicity and side bands indicators It could be sense echo signal ***Disadvantage*** The low pass filter might be average-out the variations of curvature of the spectrum
[55]	2015	FFT could practical to the analysis of electrical machineries employed in steady state, since the power spectrum is not capable to find in the time area the signal constituents	***Advantage*** It was work in periodic signals ***Disadvantage*** It was not appropriate for non-periodic signal.

[56]	2014	The vibration signal was categorized into three portions of signals like noise-only part, signal-only part and trend-only part. The approach fault-related feature extraction from subsequent signals, the haunted investigation of the empirically identified the local largeness was utilized. This method was analyzed with rare vibration signs which was created by compound motorized systems and it included with normal and fault bearing vibration data	***Advantage*** It was efficiently detected the faults It was also identified the high frequency gratified for tedious instinct services ***Disadvantage*** It was required to progress the assortment of band pass filter to achieve the demodulation process.
[57]	2014	This technique was for extracting symptoms from fault information	***Disadvantage*** Misreporting false alarm.
[58]	2015	MPE is utilized for extracting the feature to decrease the difficulty of the feature vector. Removed features are known input to the ANFC for automatic error analysis process. Vibration signs are seized for strong and defective manners.	***Disadvantage*** It was included with difficult inference Easy to misdiagnosis.
[59]	2017	A Bayesian OAASVM classifier to improve the diagnostic performance of a multi-class bearing fault diagnosis scheme. The fault diagnosis scheme used hybrid feature vectors extracted from the AEs of normal and defective bearings.	***Advantage*** Dependability of diagnosis was strong ***Disadvantage*** Consistency maintenance difficult
[60]	2015	In this work two classification techniques were used as SVM and ANN. The SVM with Gaussian kernel utility had the best accuracy in the right error diagnosis and an outstanding strength in contradiction of noise.	***Advantage*** It had simple inference and strong dependability of diagnosis ***Disadvantage*** It was short in exceptional fault
[61]	2015	The fault identification of rotating engines were advanced method which was utilized as a genetic algorithm through a new active examination approach, experiential mode decay, and ROC examination.	***Advantage*** It was used the optimum solution and also it was faster than other techniques Less computation time. ***Disadvantage*** It was only suitable for online implementation.

3. CONCLUSIONS

This paper discussed the issues in the fault diagnosis in the gear box. The major inferences are observed from the literal review regarding efficient fault diagnosis, reducing the production cost, and increased the lifetime of the machines by the earlier diagnosis the gears. By generating the six types of signals like healthy gear signal, faulty gear signal, healthy gear signal affected by noise, faulty gear signal affected by noise, distributed fault signal, and local fault signal are used to identify the machine status. The time consumption, less efficiency and cost are the major reasons for improving the fault detection methods. The brief review handled on techniques can be utilized for future research, and it helps the researchers to improve their work as, increased lifetime of the machine, reduced the fault and increased the productivity.

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